Lecture 12: Network layer mobility – Mobile IP, cellular handsoffs.

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Network layer: recap

- The network or IP layer handles routing and forwarding between IP hops in the Internet.
- You should be familiar with the following concepts from a previous basic networking course:
  - IP address, IP prefix (aggregations of IP addresses)
  - Routing tables (mapping from IP prefixes to routes; populated by routing protocols)
  - Forwarding tables (derived from routing tables; mapping from IP prefixes to best route and next hop along that route)
  - Intra-domain routing (shortest path based like OSPF) vs. inter-domain routing (handles policy as well)

Mobility in the network layer

- For mobile systems, the main challenge is to maintain connectivity and forwarding in the face of mobility.
- Two types of mobility:
  - Last hop mobility. Only the last hop in the path is wireless and mobile. E.g., wireless LANs, cellular networks.
  - Multihop networks. Many wireless hops, all of which are made up of mobile nodes. E.g., sensor networks, adhoc networks, mesh networks.
- This lecture: single hop mobility.
- Next few lectures: multihop wireless networks.

Single hop mobility

- What is the problem?
  - You are connected to a WiFi AP with a certain IP address. You then move to a different IP address. You still want to maintain your “reachability” with respect to transport and application layer protocols.
- Why this problem? TCP connections are bound to your IP address and break when your IP changes. However, you cannot usually keep your old IP in a new network, as IP address allocation is hierarchical.
- The root of the problem is that your IP address serves as both your “address” that is used to locate you, and as your “identity” that is used to identify you in TCP connections.

Single hop mobility (2)

- If you have no outstanding connections while you move, you are probably ok.
  - You can go to the new location and open new TCP connections with your new IP address.
  - If you have incoming TCP connections (e.g., web server), you can change your DNS record to reflect new IP.
- If you are okay to stop and restart your connections when you move, then we are good too.
- So, the problem for wireless LANs: how do you move and change Ips while maintaining a running TCP connection?
- Analogous problem in cellular networks: how do you keep a voice call / data session going when you move between cells?

Single hop mobility (3)

- You can handle single hop mobility in several ways:
  - Change the IP layer so that the higher layers can still operate without knowing you have moved (network layer solutions to mobility)
  - Or, change TCP so that it can cope with changing end-point identifiers (transport layer solutions to mobility)
- In this lecture, we will look at network layer solutions to mobility.
  - Mobile IP proposal to handle mobility at the IP layer
  - The analogous idea of handoffs in cellular networks

Mobile IP

- Please see the reference on the class website for a complete description.
- The setting: a mobile client in a “home network” using IP called “home address” moves to a “foreign network” and obtains a new “care-of address”.
- Mobile IP proposes the existence of “mobility agents”. A “home agent” in the home network is in charge of managing the traffic of the mobile node in its home network. An optional “foreign agent” coordinates with the home agent.
- Note: In IPv6, the foreign agent functionality is integrated into the IP stack of the mobile node itself. So, in the following discussion, foreign agent can be substituted by mobile node.

Mobile IP (2)

- Steps in Mobile IP operation:
  - When a mobile node moves to a new care-of address, it informs the home agent of its new address and period of validity. The home agent maintains the binnding (home address, care of address, duration of validity).
  - Note that the new host cannot announce a route for its home address from the new network (IP prefix won't match), so packets destined to its home address won't reach it by default.
  - When any packets arrive at the home address, the home agent tunnels those packets to the foreign agent / mobile node at its new address. IP-in-IP tunneling means that the original IP packet is encapsulated in another IP packet with the new destination address being the care of address.
  - The mobile node can send replies directly, or reverse tunnel them via home agent.

Mobile IP: issues

- Security. Any malicious node can announce a new care of address and steal packets. To prevent this, home agent and mobile node must share a secret key and authenticate their communications.
- Long routes. Packets have to travel extra distance to the home agent and back. This can be avoided in Ipv6 using source routing.
- Ingress filtering. ISPs can block packets coming from mobile nodes if the source address is their old home address and does not belong to the IP block of its current network.
- Not enough use cases. People might just prefer to cancel and restart their TCP connections when they move!

Mobility in cellular networks

- When a cell phone moves during a call, a handoff happens to ensure seamless mobility.
- Hierarchy of nodes in 3G: user equipment (UE) to base station (BS or NodeB) to radio network controller (RNC).
- During inter-BS mobility, the RNC acts as an anchor, facilitates the handoff to the new location, transfers any data packets that have arrived after handoff happened, and reroutes data packets along the new path. Similarly, the node higher up after the RNC does something similar for inter-RNC handovers.
- Handoff procedures in mobile networks are usually secure and efficient because the systems were designed with mobility in mind.

Mobility in cellular networks (2)

- Hard handoff – a mobile stops communicating with its old BS before starting communication with new BS. This is the only option in systems where adjacent cells are on different frequencies.
- Soft handoff – the mobile communicates simultaneously with both base stations in the transition period. This is possible in CDMA systems where adjacent base stations share the same frequency. Ensures a smoother transition.